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Monthly Performance Report

SOUTH DAKOTA SCHOOL OF MINES

APRIL 1979

U.S. Department of Energy

National Solar Heating and Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT
SOUTH DAKOTA SCHOOL OF MINES
APRIL 1979

I. SYSTEM DESCRIPTION

The South Dakota School of Mines solar energy system is installed in the visitors' center of the Mount Rushmore National Memorial at Keystone, South Dakota. The solar energy system is a retrofit to the original heating and cooling system, and is designed to provide 45 percent of the annual heating requirements for the entire building and provide 53 percent of the annual air conditioning requirements for the observation room.

Solar energy collection is performed by 112 double-glazed, flat-plate collectors manufactured by Lennox Industries, Inc., that have a gross area of 2,000 square feet. The collectors are mounted in six arrays on the roof of the building, and face 19 degrees west of south with a tilt of 46 degrees from the horizontal. The main system loop contains 150 gallons of 50 percent ethylene glycol and water solution, which is used to transfer energy, as required, from the collector to the collector-to-storage heat exchanger, the collector-to-space heating heat exchanger, and Arkla absorption chillers. Thermal storage is provided by 3,000 gallons of water in a steel storage tank that is insulated with three inches of fiberglass.

Heating demands are met by transferring energy from the collector, or storage, to heating coils in the building multizone air handler. The multizone fan is energized continuously to circulate building air, and dampers in the multizone unit are positioned to allow flow across the solar heating coil when the system is in a solar heating mode. Auxiliary heating is provided by a two-stage fuel oil furnace.

Thermal energy from the collectors is used to operate three absorption chillers; chilled water from these chillers is circulated through a cooling coil in the observation room air handler. Thermal energy from storage is

not used to operate the chillers because of temperature limitations. Auxiliary cooling is provided to both the multizone and single-zone air handlers by vapor compression units.

This system, which is shown schematically in Figure 1, has six modes of solar operation.

Mode 1 - Solar Energy Collection: The solar collection mode is entered when the collector absorber plate temperature is greater than 100°F. In this mode, pump P1 is energized and valve V4 is positioned to allow flow through the collectors. This mode is entered even though there is no heating or cooling load and storage tank charging criteria have not been met. This mode continues until the collector plate temperature is less than 100°F; however, an adjustable time-delay circuit delays pump P1 shutdown to prevent short cycling.

Mode 2 - First Stage Heating From Collectors: This mode is entered when the system is in the collection mode and a demand for heat is determined by the difference between the conditioned space thermostat setting and the discharge air temperature in the multizone air handler. In this mode, valve V7 is positioned to allow flow through the heating coil HX2 located in the multizone air handler, and valve V5 is positioned to bypass the absorption chillers. Flow through the heating coil is provided by pump P1. If the heating demand cannot be met using solar energy, a fuel-oil furnace is used in conjunction with, and independent of, solar heating.

Mode 3 - First Stage Heating From Storage: This mode is entered when there is a heating demand, energy is not available from the collectors, and energy is available from storage because the top tank temperature is greater than 100°F. In this mode, valves V5 and V7 are in the heating positions, and valve V4 is in the collection bypass position. Valves V1 and V2 are positioned to allow flow into the bottom and out of the top of the storage tank. Pump P2 is energized to circulate water between the storage tank and the water side of the storage heat exchanger HX1, and pump P1 is energized to circulate the main system fluid between the glycol/water side of heat

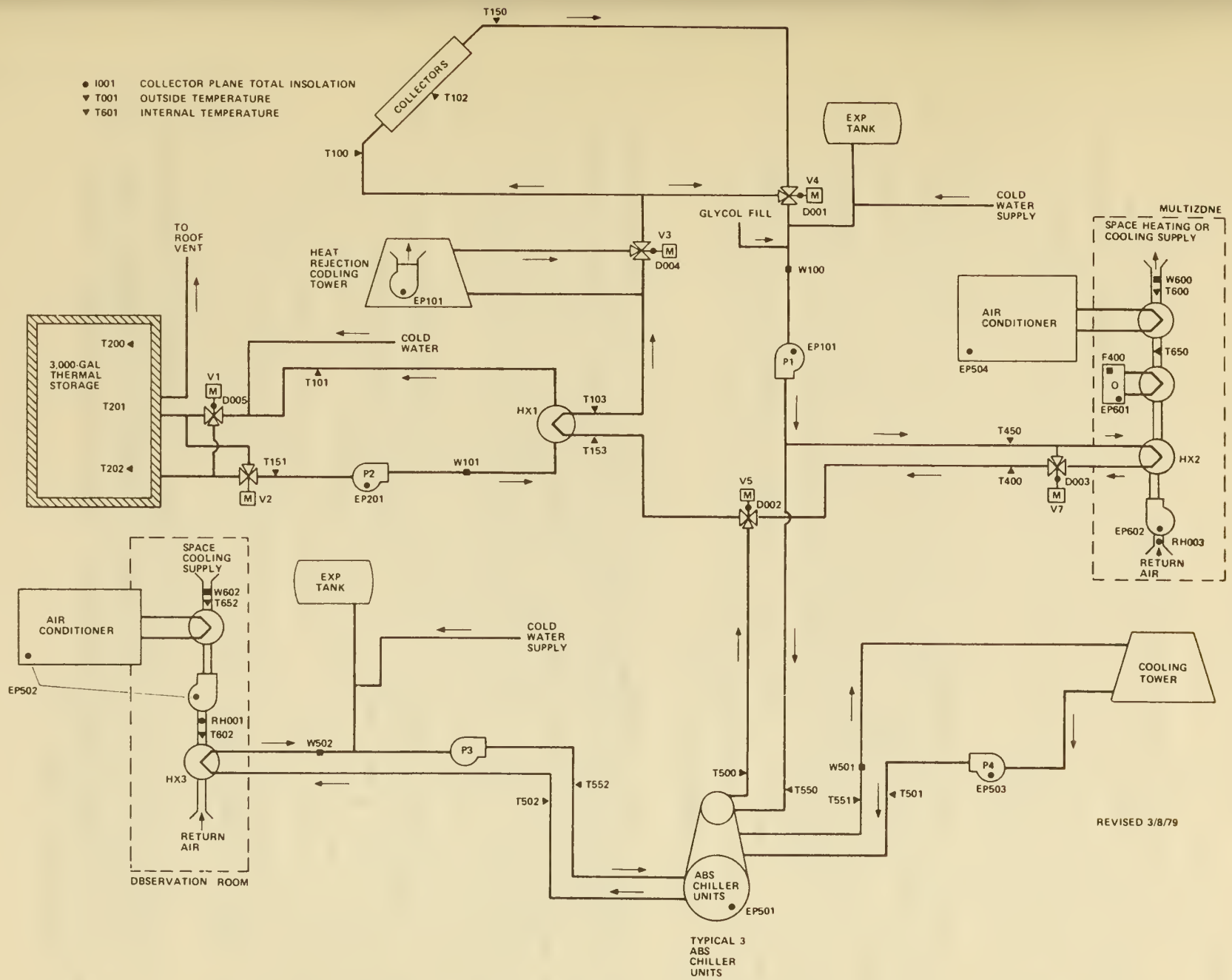

Figure 1. SOUTH DAKOTA SCHOOL OF MINES SOLAR ENERGY SYSTEM SCHEMATIC

exchanger HX1 and the liquid side of heating coil HX2 in the air handler. Multizone air handler and oil furnace operations are the same as described in Mode 2.

Mode 4 - Single-Zone Cooling From Collectors: This mode is entered when sufficient solar energy from the collectors is available, and when a demand for single-zone cooling is determined by the conditioned space thermostat (located in the observation room) and the discharge air temperature of single-zone air handler.

Since generator inlet temperatures of 180°F are required in order to operate the absorption chillers, this mode is not allowed until collector outlet temperatures reach this level. If temperature requirements are met, valve V5 is positioned to allow flow through the chillers' generators, provided that pump P3 is operating to circulate chilled water through the solar cooling coils. Pump P4 is energized to circulate condensing water through the cooling tower. The cooling tower fan is controlled by an aquastat to maintain a sump temperature of 85°F.

Safety cutoffs are also provided to prevent either overheating or excessive cooling of the chillers. No solar cooling from the storage mode is provided since maximum storage tank temperature and energy losses prohibit efficient operation of the chillers. Auxiliary cooling will be provided by vapor compression units (A/C unit) in the single-zone and multizone air handlers.

Mode 5 - Storage Tank Charging: This mode is entered when the inlet temperature on the glycol/water side of the storage heat exchanger is 20°F greater than the storage tank bottom temperature. This mode is also entered in the cooling mode if, in addition to being 20°F greater than the storage temperature, the heat exchanger inlet temperature (glycol/water side) is greater than 195°F.

In this mode, valves V1 and V2 are positioned to allow flow into the top and out of the bottom of storage, and pump P2 is energized to circulate water from storage through the heat exchanger. This mode is stopped if storage tank temperatures exceed 205°F.

Mode 6 - Excess Heat Rejection: This mode is entered when the storage heat exchanger outlet temperature T103 exceeds 205°F. In this mode, valve V3 is positioned to allow flow through the heat rejection cooling tower. The fan in this tower is controlled by an aquastat to maintain a sump temperature of 195°F.

II. PERFORMANCE EVALUATION

The system performance evaluations discussed in this section are based primarily on the analysis of the data presented in the attached computer-generated monthly report. This attached report consists of daily site thermal and energy values for each subsystem, plus environmental data. The performance factors discussed in this report are based upon the definitions contained in NBSIR 76-1137, Thermal Data Requirements and Performance Evaluation Procedures for the National Solar Heating and Cooling Demonstration Program.

A. Introduction

The Mount Rushmore Visitors' Center solar energy system was operational throughout the month of April 1979. The most significant change in system performance for April, compared with March, was the reduction in energy supplied from storage to the heating load. During April, only 3.9 million Btu were supplied from storage compared with 10.5 million Btu supplied from storage during March. This factor is attributed to the moderating nighttime temperatures and the reduction in total building heat load from 50.2 million Btu in March to 31.2 million Btu in April.

B. Weather

During April, the average measured outside temperature was 42°F, 3°F below the long-term average temperature for the Rapid City, South Dakota area. The average measured insolation in the plane of the collector was 1,573 Btu/ft^2-day, five percent below the long-term average of 1,658 Btu/ft^2-day. Long-term environmental data are derived from data supplied by Reference

Monthly Environmental Data for Systems in the National Solar Data Network (Department of Energy Report - SOLAR/0019-79/36).

C. System Thermal Performance

Collector - During the reporting period, a total of 94.4 million Btu of incident solar energy was measured in the plane of the collector array. The system collected 22.4 million Btu or 24 percent of the total available insolation. During the time the system was operating, a total of 76.2 million Btu was incident on the array. This represents an operational collector efficiency of 29 percent. A total of 0.29 million Btu of electrical energy was required to collect solar energy when the system was operating in the collection/storage modes.

Storage - Storage calculations show that 11.24 million Btu were delivered to storage during the month and 3.88 million Btu were supplied from storage to the heating load. Storage losses included 5.39 million Btu from the storage tank, and an additional 0.75 million Btu from the collector loop-to-storage loop heat exchanger. A net increase in stored energy of 1.97 million Btu was observed over the month. The monthly storage efficiency was 52 percent. This decrease from the March value is due to the elevated average tank temperature and resultant increased thermal losses from the tank. The average storage tank temperature was 161°F in April compared to 141°F in March.

Space Heating Load - The space heating load for April was 31.23 million Btu. Solar energy supplied 9.03 million Btu which represents a heating solar fraction of 29 percent. An average building temperature of 66°F was maintained during April.

Of the 9.03 million Btu of solar energy supplied to the space heating load, 5.90 million Btu came directly from the collector and the balance of 3.13 million Btu were supplied from storage. Operating energy required to deliver solar energy to the heating load amounted to 0.76 million Btu for the month. A total of 0.98 million Btu of solar energy was intentionally rejected by the heat rejection cooling tower.

D. Observations

A comparison of the sum of solar energy loads and losses with the value of solar energy collected, as presented in this report, shows an apparent energy imbalance of 4.2 million Btu. This imbalance is attributed to leakage through collector bypass value V4 which is known to have a faulty actuator, preventing proper seating of this valve. Since the value of solar energy collected is computed on the basis of full rated flow through the collector array, it is in error by the amount of the leakage through V4. The tabulation showing this imbalance is given below:

Solar Energy Loads/Losses (Million Btu)

Stored Energy Input:	11.240
Direct Input From Collector:	5.900
Rejected Solar Energy:	0.975
Storage HX Loss (Storage Pump Off):	0.072
Sum:	18.187
Solar Energy Collected (Million Btu):	22.380
Sum Of Loads/Losses:	-18.187
Apparent Imbalance:	4.193

Assuming that the leakage through valve V4 is 18 percent of rated flow, when the collector loop is active, the value of solar energy collected would be reduced to 82 percent of its present value of 18.352 million Btu, eliminating the apparent imbalance.

E. Energy Savings

The solar energy system at Mount Rushmore provided a savings of 15.06 million Btu of fossil fuel during April, a decrease of 8.28 million Btu compared with the savings in March. This savings was realized at the cost of 0.29 million Btu of electrical operating energy for the solar energy system.

III. ACTION STATUS

Analysis of the April data indicates that the sensor T400, heating coil outlet sensor, is in error and computations of solar energy supplied to the building heat load were based, instead, on measurements at sensor T153, located at the inlet of heat exchanger HX1. Sensor T400 will be repaired or replaced during a site visit in early June.

The faulty actuator on valve V4 is presently scheduled for replacement during the month of June.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD — SOLAR/2019-79/04
REPORT PERIOD: APRIL,1979

SITE/SYSTEM DESCRIPTION:
THE SOUTH DAKOTA SCHOOL OF MINES SOLAR SYSTEM IS DESIGNED TO CARRY ABOUT 50% OF THE HEATING LOAD AND ABOUT 40% OF THE COOLING LOAD. SECOND STAGE HEATING WILL BE PROVIDED BY A TWO STAGE FUEL OIL BURNER AND SECOND STAGE COOLING WILL BE PROVIDED BY A REFRIGERATION COMPRESSOR IN THE MULTIZONE UNIT AND A SINGLE ZONE 10-TON PACKAGE UNIT. THE SOLAR SYSTEM WILL UTILIZE 1692 SQ-FT OF DOUBLE COVER, SELECTIVE COATED, FLAT PLATE COLLECTORS, HEATING COILS IN THE MULTI-ZONE UNIT, THREE CHILLERS, COOLING TOWER, COOLING COILS IN THE SINGLE ZONE UNIT, AND 3000 GAL. WATER STORAGE TANK.

GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	94.397 MILLION BTU
	47198 BTU/SQ.FT.
COLLECTED SOLAR ENERGY	22.377 MILLION BTU
	11188 BTU/SQ.FT.
AVERAGE AMBIENT TEMPERATURE	42 DEGREES F
AVERAGE BUILDING TEMPERATURE	66 DEGREES F
ECSS SOLAR CONVERSION EFFICIENCY	0.10
ECSS OPERATING ENERGY	0.290 MILLION BTU
TOTAL SYSTEM OPERATING ENERGY	1.046 MILLION BTU
TOTAL ENERGY CONSUMED	60.416 MILLION BTU

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	31.231	0.000	31.231 MILLION BTU
SOLAR FRACTION	N.A.	29	0	29 PERCENT
SOLAR ENERGY USED	N.A.	9.035	0.000	9.035 MILLION BTU
OPERATING ENERGY	N.A.	0.756	0.000	1.046 MILLION BTU
AUX. THERMAL ENERGY	N.A.	22.265	0.000	22.196 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	0.000	0.000 MILLION BTU
AUX. FOSSIL FUEL	N.A.	37.108	N.A.	37.108 MILLION BTU
ELECTRICAL SAVINGS	N.A.	-0.526	0.000	-0.815 MILLION BTU
FOSSIL SAVINGS	N.A.	15.058	N.A.	15.058 MILLION BTU

SYSTEM PERFORMANCE FACTOR: 0.769

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SITE SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: APRIL,1979

SOLAR/2019-79/04

SITE/SYSTEM DESCRIPTION:
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GENERAL SITE DATA:

INCIDENT SOLAR ENERGY	99.588	GIGA JOULES
	535985	KJ/SQ.M.
COLLECTED SOLAR ENERGY	23.607	GIGA JOULES
	127055	KJ/SQ.M.
AVERAGE AMBIENT TEMPERATURE	6	DEGREES C
AVERAGE BUILDING TEMPERATURE	19	DEGREES C
ECSS SOLAR CONVERSION EFFICIENCY	0.10	
ECSS OPERATING ENERGY	0.306	GIGA JOULES
TOTAL SYSTEM OPERATING ENERGY	1.103	GIGA JOULES
TOTAL ENERGY CONSUMED	63.739	GIGA JOULES

SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	32.949	0.000	32.949 GIGA JOULES
SOLAR FRACTION	N.A.	29	0	29 PERCENT
SOLAR ENERGY USED	N.A.	9.532	0.000	9.532 GIGA JOULES
OPERATING ENERGY	N.A.	0.798	0.000	1.103 GIGA JOULES
AUX. THERMAL ENG	N.A.	23.489	0.000	23.417 GIGA JOULES
AUX. ELECTRIC FUEL	N.A.	N.A.	0.000	0.000 GIGA JOULES
AUX. FOSSIL FUEL	N.A.	39.149	N.A.	39.149 GIGA JOULES
ELECTRICAL SAVINGS	N.A.	-0.555	0.000	-0.860 GIGA JOULES
FOSSIL SAVINGS	N.A.	15.886	N.A.	15.886 GIGA JOULES

SYSTEM PERFORMANCE FACTOR: 0.769

* DENOTES UNAVAILABLE DATA
@ DENOTES NULL DATA
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT OF THE NATIONAL SOLAR DATA PROGRAM,FEBRUARY 28,1978, SOLAR/0004-78/18

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENERGY COLLECTION AND STORAGE SUBSYSTEM (ECSS)

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: APRIL,1979

SOLAR/2019-79/04

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	AMBIENT TEMP DEG-F	ENERGY TO LOADS MILLION BTU	AUX THERMAL TO ECSS MILLION BTU	ECSS OPERATING ENERGY MILLION BTU	ECSS ENERGY REJECTED MILLION BTU	ECSS SOLAR CONVERSION EFFICIENCY
1	0.477	21	0.000	N	0.000	0.000	0.000
2	0.796	23	0.000	O	0.000	0.000	0.000
3	4.108	32	0.190	T	0.016	0.000	0.046
4	3.825	33	0.387		0.023	0.000	0.101
5	1.350	23	0.321	A	0.001	0.000	0.238
6	4.526	51	0.233	P	0.025	0.000	0.051
7	4.355	50	0.290	P	0.020	0.000	0.067
8	4.525	42	0.486	L	0.019	0.000	0.107
9	4.491	52	0.428	I	0.017	0.000	0.095
10	1.859	42	0.183	C	0.000	0.000	0.098
11	0.421	28	0.000	A	0.000	0.000	0.000
12	1.300	26	0.198	B	0.000	0.000	0.152
13	3.537	38	0.582	L	0.011	0.000	0.165
14	4.645	43	0.527	E	0.021	0.000	0.113
15	3.384	53	0.325		0.014	0.000	0.096
16	4.205	55	0.417		0.017	0.000	0.099
17	3.598	60	0.174		0.018	0.039	0.048
18	4.210	64	0.009		0.023	0.433	0.002
19	3.113	47	0.380		0.004	0.123	0.122
20	3.695	43	0.499		0.001	0.020	0.135
21	2.650	49	0.380		0.001	0.000	0.143
22	4.166	48	0.414		0.011	0.020	0.099
23	3.974	55	0.468		0.007	0.341	0.118
24	1.345	42	0.105		0.000	0.000	0.078
25	2.706	41	0.343		0.001	0.000	0.127
26	2.669	39	0.317		0.003	0.000	0.119
27	4.523	38	0.401		0.016	0.000	0.089
28	3.384	41	0.277		0.006	0.000	0.082
29	2.656	40	0.327		0.004	0.000	0.123
30	3.904	46	0.376		0.010	0.000	0.096
SUM	94.397	-	9.035	N.A.	0.290	0.975	-
AVG	3.147	42	0.301	N.A.	0.010	0.033	0.096
NBS ID	Q001	N113			Q102		N111

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
COLLECTOR ARRAY PERFORMANCE

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD SOLAR/2019-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	INCIDENT SOLAR ENERGY MILLION BTU	OPERATIONAL INCIDENT ENERGY MILLION BTU	COLLECTED SOLAR ENERGY MILLION BTU	DAYTIME AMBIENT TEMP DEG F	COLLECTOR ARRAY EFFICIENCY
1	0.477	0.000	0.000	22	0.000
2	0.796	0.000	0.000	26	0.000
3	4.108	2.400	0.883	40	0.215
4	3.825	3.162	1.177	40	0.308
5	1.350	0.186	0.105	23	0.078
6	4.526	4.003	1.565	63	0.346
7	4.355	3.842	1.266	57	0.291
8	4.525	4.309	1.221	52	0.270
9	4.491	4.047	1.137	64	0.253
10	1.859	1.350	0.246	51	0.132
11	0.421	0.000	0.000	28	0.000
12	1.300	0.000	0.000	28	0.000
13	3.537	3.256	0.986	46	0.279
14	4.645	4.287	1.446	53	0.311
15	3.384	2.732	0.900	67	0.266
16	4.205	3.743	1.178	65	0.280
17	3.598	3.139	0.786	67	0.218
18	4.210	3.504	1.108	79	0.263
19	3.113	2.675	0.610	55	0.196
20	3.695	3.217	0.713	53	0.193
21	2.650	2.191	0.493	57	0.186
22	4.166	3.688	1.014	56	0.243
23	3.974	3.632	1.249	63	0.314
24	1.345	0.693	0.112	45	0.083
25	2.706	2.194	0.518	48	0.192
26	2.669	2.174	0.459	47	0.172
27	4.523	3.843	1.204	49	0.266
28	3.384	2.640	0.607	47	0.179
29	2.656	1.991	0.453	52	0.171
30	3.904	3.342	0.942	58	0.241
SUM	94.397	76.242	22.377	-	-
AVG	3.147	2.541	0.746	50	0.237
NBSID	Q001		Q100		N100

* DENOTES UNAVAILABLE DATA.
ø DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTPATION PROGRAM

MONTHLY REPORT
STORAGE PERFORMANCE

SITE: SOUTH DAKOTA SCHOOL CF MINES, SD SOLAR/2019-79/04
REPORT PERIOD: APRIL,1979

DAY OF MONTH	ENERGY TO STORAGE MILLION BTU	ENERGY FROM STORAGE MILLION BTU	CHANGE IN STORED ENERGY MILLION BTU	STORAGE AVERAGE TEMP DEG F	STORAGE EFFICIENCY
1	0.000	0.000	-0.041	102	1.000
2	0.000	0.000	-0.055	100	1.000
3	0.734	0.190	0.430	110	0.844
4	0.927	0.457	0.359	121	0.880
5	0.020	0.626	-0.617	107	0.444
6	1.251	0.000	1.124	126	0.899
7	0.858	0.000	0.645	163	0.752
8	0.774	0.576	0.005	169	0.750
9	0.612	0.000	0.361	184	0.590
10	0.000	0.000	-0.278	187	1.000
11	0.000	0.000	-0.196	177	1.000
12	0.000	0.420	-0.511	161	1.000
13	0.589	0.661	-0.105	142	0.945
14	1.011	0.456	0.417	147	0.864
15	0.666	0.492	0.014	155	0.760
16	0.639	0.000	0.427	173	0.668
17	0.507	0.000	0.242	186	0.478
18	0.344	0.000	0.167	197	0.484
19	0.020	0.000	-0.218	196	-11.131
20	0.052	0.000	-0.163	187	-3.122
21	0.042	0.000	-0.226	180	-5.321
22	0.454	0.000	0.234	179	0.516
23	0.229	0.000	0.003	184	0.014
24	0.000	0.000	-0.261	179	1.000
25	0.036	0.000	-0.182	170	-4.997
26	0.100	0.000	-0.077	164	-0.770
27	0.666	0.000	0.450	171	0.676
28	0.175	0.000	-0.064	179	-0.368
29	0.099	0.000	-0.140	176	-1.418
30	0.434	0.000	0.221	176	0.510
SUM	11.238	3.877	1.967	-	-
AVG	0.375	0.129	0.066	162	0.520
NBS ID	Q200	Q201	Q202		N108

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE HEATING SUBSYSTEM

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: APRIL,1979

SCLAR/2019-79/04

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR.OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AME TEMP DEG. F
1	1.356	0	0.000	0.022	1.356	N	2.261	0.000	0.000	61	21
2	1.205	0	0.000	0.020	1.274	O	2.123	0.000	0.000	61	23
3	1.287	15	0.190	0.031	1.097	T	1.829	-0.017	0.316	62	32
4	1.648	23	0.387	0.048	1.261		2.101	-0.035	0.645	62	33
5	1.984	16	0.321	0.058	1.662	A	2.771	-0.041	0.535	61	23
6	1.359	17	0.233	0.026	1.126	P	1.877	-0.015	0.388	66	51
7	0.985	29	0.290	0.023	0.695	P	1.158	-0.015	0.483	67	50
8	1.101	44	0.486	0.035	0.615	L	1.025	-0.029	0.810	66	42
9	0.827	52	0.428	0.026	0.399	I	0.665	-0.022	0.713	68	52
10	0.651	28	0.183	0.016	0.468	C	0.780	-0.012	0.305	66	42
11	1.243	0	0.000	0.011	1.243	A	2.072	0.000	0.000	62	28
12	2.102	9	0.198	0.022	1.903	B	3.172	-0.007	0.330	61	26
13	1.586	37	0.582	0.051	1.004	L	1.673	-0.041	0.971	63	38
14	1.464	36	0.527	0.045	0.937	E	1.562	-0.035	0.878	65	43
15	0.989	33	0.325	0.030	0.664		1.107	-0.024	0.541	68	53
16	0.808	52	0.417	0.025	0.392		0.653	-0.021	0.694	70	55
17	0.254	68	0.174	0.007	0.080		0.134	-0.006	0.290	69	60
18	0.009	100	0.009	0.001	0.000		0.000	-0.001	0.015	70	64
19	0.497	76	0.380	0.016	0.117		0.195	-0.015	0.633	70	47
20	0.888	56	0.499	0.024	0.389		0.648	-0.021	0.831	68	43
21	0.831	46	0.380	0.025	0.451		0.752	-0.020	0.633	68	49
22	0.816	51	0.414	0.024	0.402		0.669	-0.020	0.691	70	48
23	0.579	81	0.468	0.021	0.110		0.184	-0.021	0.780	70	55
24	0.265	39	0.105	0.011	0.161		0.268	-0.010	0.175	66	42
25	0.837	41	0.343	0.023	0.494		0.824	-0.019	0.571	66	41
26	1.006	32	0.317	0.023	0.689		1.149	-0.018	0.529	65	39
27	1.253	32	0.401	0.024	0.852		1.420	-0.018	0.668	66	38
28	1.158	24	0.277	0.019	0.881		1.469	-0.011	0.461	67	41
29	1.183	28	0.327	0.023	0.856		1.426	-0.014	0.545	65	40
30	1.061	35	0.376	0.026	0.685		1.142	-0.019	0.627	67	46
SUM	31.231	-	9.035	0.756	22.265	N.A.	37.108	-0.526	15.058	-	-
AVG	1.041	29	0.301	0.025	0.742	N.A.	1.237	-0.018	0.502	66	42
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

* DENOTES UNAVAILABLE DATA.
@ DENOTES NULL DATA.
N.A. DENOTES NOT APPLICABLE DATA.

SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
SPACE COOLING SUBSYSTEM

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: APRIL,1979

SOLAR/2019-79/04

DAY OF MON.	SPACE COOLING LOAD MILLION BTU	SOLAR FR. OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION ETU	BLDG DRY BULB TEMP F	AMB TEMP DEG F
1	0.000	0	0.000	0.000	0.000	0.000	N	0.000	N	61	21
2	0.000	0	0.000	0.000	0.000	0.000	O	0.000	O	61	23
3	0.000	0	0.000	0.000	0.000	0.000	T	0.000	T	62	32
4	0.000	0	0.000	0.000	0.000	0.000		0.000		62	33
5	0.000	0	0.000	0.000	0.000	0.000	A	0.000	A	61	23
6	0.000	0	0.000	0.000	0.000	0.000	P	0.000	P	66	51
7	0.000	0	0.000	0.000	0.000	0.000	P	0.000	P	67	50
8	0.000	0	0.000	0.000	0.000	0.000	L	0.000	L	66	42
9	0.000	0	0.000	0.000	0.000	0.000	I	0.000	I	68	52
10	0.000	0	0.000	0.000	0.000	0.000	C	0.000	C	66	42
11	0.000	0	0.000	0.000	0.000	0.000	A	0.000	A	62	28
12	0.000	0	0.000	0.000	0.000	0.000	B	0.000	B	61	26
13	0.000	0	0.000	0.000	0.000	0.000	L	0.000	L	63	38
14	0.000	0	0.000	0.000	0.000	0.000	E	0.000	E	65	43
15	0.000	0	0.000	0.000	0.000	0.000		0.000		68	53
16	0.000	0	0.000	0.000	0.000	0.000		0.000		70	55
17	0.000	0	0.000	0.000	0.000	0.000		0.000		69	60
18	0.000	0	0.000	0.000	0.000	0.000		0.000		70	64
19	0.000	0	0.000	0.000	0.000	0.000		0.000		70	47
20	0.000	0	0.000	0.000	0.000	0.000		0.000		68	43
21	0.000	0	0.000	0.000	0.000	0.000		0.000		68	49
22	0.000	0	0.000	0.000	0.000	0.000		0.000		70	48
23	0.000	0	0.000	0.000	0.000	0.000		0.000		70	55
24	0.000	0	0.000	0.000	0.000	0.000		0.000		66	42
25	0.000	0	0.000	0.000	0.000	0.000		0.000		66	41
26	0.000	0	0.000	0.000	0.000	0.000		0.000		65	39
27	0.000	0	0.000	0.000	0.000	0.000		0.000		66	38
28	0.000	0	0.000	0.000	0.000	0.000		0.000		67	41
29	0.000	0	0.000	0.000	0.000	0.000		0.000		65	40
30	0.000	0	0.000	0.000	0.000	0.000		0.000		67	46
SUM	0.000	-	0.000	0.000	0.000	0.000	N.A.	0.000	N.A.	-	-
AVG	0.000	0	0.000	0.000	0.000	0.000	N.A.	0.000	N.A.	66	42
NBS	Q502	N500	C500	Q503	C501		Q508	Q512	C514	N406	N113

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SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

MONTHLY REPORT
ENVIRONMENTAL SUMMARY

SITE: SOUTH DAKOTA SCHOOL OF MINES, SD
REPORT PERIOD: APRIL,1979

SOLAR/2019-79/04

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	238	N	21	22	N	N	N
2	398	O	23	26	O	O	O
3	2054	T	32	40	T	T	T
4	1913		33	40			
5	675	A	23	23	A	A	A
6	2263	P	51	63	P	P	P
7	2178	P	50	57	P	P	P
8	2262	L	42	52	L	L	L
9	2246	I	52	64	I	I	I
10	929	C	42	51	C	C	C
11	210	A	28	28	A	A	A
12	650	B	26	28	B	B	B
13	1768	L	38	46	L	L	L
14	2322	E	43	53	E	E	E
15	1692		53	67			
16	2102		55	65			
17	1799		60	67			
18	2105		64	79			
19	1557		47	55			
20	1848		43	53			
21	1325		49	57			
22	2083		48	56			
23	1987		55	63			
24	672		42	45			
25	1353		41	48			
26	1335		39	47			
27	2261		38	49			
28	1692		41	47			
29	1328		40	52			
30	1952		46	58			
SUM	47198	N.A.	-	-	-	-	-
AVG	1573	N.A.	42	50	N.A.	N.A.	N.A.
NBS ID	Q001		N113			N115	N114

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